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Military expenditure summarizes the flow of resources in the defense sector during some period of time; military force potential is a measure of the military output that can be produced with all the assets of the defense establishment, many of which are acquired over an extended period of time. The analysis presents a measure of military output called force potential, which adjusts military expenditure to compensate for the durable character of many military assets. Soviet military expenditure information and hypothetical military capital stock series for the Soviet Union are used to compute the growth of military force potential for 1967-1972. Also proposed is an indicator of the relative military power position of the United States in the long-term competition with the Soviet Union.

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Lt. Col. Gregory G. Hildebrandt

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PREFACE

Soviet military expenditure represses current consumption as well as economic growth and development; this is the effect of defense on the Soviet economy. Conversely, resource constraints may affect current military capability as well as the evolution of the Soviet military posture; this is the effect of the Soviet economy on defense. Various dimensions of these interdependent relationships are being investigated in a series of studies that are part of a Project AIR FORCE project, "Soviet Strategic Competitiveness: Constraints and Opportunities." This report examines the relationship between the flow of resources in the defense sector—the expenditure on inputs—and the military capability produced—the output that is called force potential.

The key ingredient for relating military expenditure and force potential is the military capital stock. Section II explores some features of military capital, including the important concept of the value of capital services. Section III examines the expenditure-output relationship; hypothetical data are used to compute force potential for the Soviet Union. In Sec. IV, an index of relative military power is developed that relates the force potential of the United States and the Soviet Union.

The study is an outgrowth of a suggestion by J. Dale Pafenberg, Special Advisor to the Assistant Chief of Staff for Intelligence, Hq USAF, that the policy implications of a military capital estimate be part of the Project AIR FORCE investigation. A companion report, G. G. Hildebrandt, *The Economics of Military Capital*, The Rand Corporation, R-2665-AF, August 1980, develops the principles of military capital at a more technical level. Both reports were completed while the author was on a one-year military assignment to The Rand Corporation.

SUMMARY

Military expenditure and military capability are not synonymous. Military expenditure summarizes the flow of resources in the defense sector; military capability is the output that can be produced with all the assets of the defense establishment, many of which are acquired over an extended period of time. The report develops a measure of output called *military force potential*, which adjusts military expenditure to compensate for the durable character of many military assets. The adjustment makes extensive use of the military capital stock—a summary measure of all the durable physical assets in the military arsenal.

Section II contains a discussion of some aspects of the military capital stock. The military capital stock equals the cost using base period prices of depreciated military equipment facilities and inventories. It is shown that there is an *imputed expenditure* each period that can be associated with each type of military capital consisting of the opportunity cost of having resources tied up in military capital, the depreciation cost and capital losses incurred during the period, and the outlays required to maintain the capital stock. Imputed expenditure (also called the value of capital services) plays an important role in the estimation of military force potential.

Section III develops the military force potential index in detail. The index equals the imputed cost of achieving a level of military output, including the expenditure on manpower, the imputed cost of capital, and the outlays on material items such as fuel and other nondurable inputs. Military force potential is the expenditure required to support the current forces of the defense establishment. Imputed expenditure can also be used to measure output because both this expenditure and military output increase and decrease together. As long as there is no change in relative prices, when military output rises or falls, so must imputed expenditure. Therefore, imputed expenditure—the military force potential index—can be used to determine whether military output is increasing.

Section III also includes a discussion of important differences between military expenditure and the military force potential index. Military force potential summarizes the output that can be achieved from current forces in a given period, whereas military expenditure includes outlays that are directed toward future increases in military capability. This future directed expenditure equals the net investment that increases the subsequent period's capital stock, and also the outlay on Research, Development, Test and Evaluation (RDT&E). Military expenditure also excludes the interest cost of capital and the capital loss resulting from reductions in the price of military assets, both of which are included in the military force potential indicator and are part of capital's imputed cost. To compute military force potential, it is necessary to deduct from military expenditure net investment and the RDT&E outlay, and add to expenditure the interest cost and capital loss cost that are associated with the military capital stock.

This adjustment is made to Soviet expenditure data for 1967, 1972, and 1977. The CIA has estimated that this expenditure has been growing at an annual rate of about 4 to 5 percent. Estimates have also been provided of the major resource categories of defense spending including gross investment and RDT&E. However, there is no readily available capital stock series for the Soviet military establishment. Several assumptions, including that U.S. military service lives can be used to approximate those in the Soviet Union, make it possible to develop a hypothetical military capital stock series. This series is used to identify the net investment and the interest cost of capital (a 12 percent interest rate is used). Military force potential is then

derived from military expenditure for the three years selected. The calculated annual growth rate of military force potential is approximately equal to the growth rate for military expenditure—a result that is retained when the service life assumption is varied.

Although military force potential measures the absolute level of military output, the achievement of national security is inherently a relative process. Section IV proposes an indicator of relative military power that summarizes changes in the military position of the United States in the long-term competition with the Soviet Union—the percentage change in the ratio of the U.S. to the Soviet military force potential. For 1972-1977, there is a calculated decline in U.S. military force potential of about 10 percent. A comparison of this decline with the calculated gain in Soviet military force potential indicates a reduction in U.S. relative military power.

Although the assumptions required to measure Soviet military force potential prevent any firm conclusions about either the change in Soviet military capability or U.S. military status in the long-term competition, the analysis does point to the importance of identifying the size of the Soviet military capital stock. This stock is the key ingredient of a movement from expenditure to military output. The index numbers that can be constructed with the aid of a military capital stock series help one understand the degree to which U.S. national security is achieved.

ACKNOWLEDGMENTS

This research project was conducted under the direction of Abraham Becker. Without his contribution this project would not have been possible. I also wish to thank Abram Bergson and Mark Hopkins for their careful reviews. The final product was greatly influenced by their comments. No thanks would be complete without mentioning Ruthlouise Acar who remained patient through several revisions of this report, and indeed, often made the suggestions for revisions. Finally, I wish to thank the United States Air Force for providing me with the opportunity to conduct this research during a one-year military assignment to The Rand Corporation.

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I. INTRODUCTION

The estimates of Soviet military expenditure (ME), which are made in both ruble and dollar terms, are very helpful for identifying the burden of defense to the Soviets and for sizing their defense expenditure relative to that of the United States. This expenditure equals the financial outlay incurred during some specified time period and provides an accounting of the resource flow in the Soviet defense sector.

The Central Intelligence Agency estimates this resource flow for three categories: Investment, Operating, and RDT&E (research, development, testing and evaluation). The investment category includes the expenditure on weapon systems, major spares, and facilities during a given period. The total expenditure in this category is sometimes called gross investment. Operating expenditure includes personnel costs and the operation and maintenance costs of existing assets. The acquisition of material inputs such as the fuel needed to operate military equipment is an operating expenditure. In the time period 1966-1977, the CIA has estimated an annual growth rate for ME of between 4 and 5 percent measured in ruble terms. During the 1970s, the growth rate averaged about 3 percent a year when ME is measured in dollar terms.¹

Although military expenditure is sometimes used as a proxy for military capability, they are really different concepts. Admiral Stansfield Turner, Director of the CIA, has stated:

Ruble and dollar cost estimates cannot be used alone . . . to draw inferences about the relative military effectiveness or capabilities of U.S. and Soviet forces. These judgments require much other data, including the size and technical characteristics of the forces, geographic locations, the allied capabilities, strategic doctrine, and tactical concepts, morale, command and control, and so on.²

Many factors apparently influence military capability. However, according to A. W. Marshall, attempts at measuring relative military effectiveness have often been descriptions of the U.S. and Soviet orders of battle, the other factors being ignored:

Most attempts to explicitly measure military power are mere tabulations of forces of various sorts: the numbers of men under arms, the numbers of weapons of a given type, etc. This is itself an evasion of the problem of estimating military power, since it says nothing about the actual capabilities of the forces of one country to deal with another.³

Although relative military effectiveness seems to be a multidimensional set of attributes, there is still a demand for an aggregate (or macro) indicator that might be used with the various micro-indicators to monitor the military status of the long-term competition. Military expenditure information is the appropriate starting point to construct such a measure. When weapons are acquired, maintained, manned, and operated by a military establishment, resources are expended by a decisionmaker who takes account of the multiple dimensions of relative military

¹CIA, *Estimated Soviet Defense Spending: Trends and Prospects*, SR78-10121, June 1978, p. i; and CIA, *Soviet and U.S. Defense Activities, 1970-79: A Dollar Cost Comparison*, SR 80-10005, January 1980, p. 3.

²*Allocation of Resources in the Soviet Union and China—1978*, Hearings Before the Subcommittee in Priorities and Economy in Government of the Joint Economic Committee, U.S. Congress, Part 4—Soviet Union, Washington, D.C., 1978, p. 38.

³A. W. Marshall, *Problems of Estimating Military Power*, The Rand Corporation, P-3417, August 1966.

effectiveness and in the process reveals how the different military assets are valued in monetary terms. Money is the most convenient yardstick for constructing an aggregate index.

Annual military expenditure is not by itself the appropriate measure. Many of the military assets—such as the tanks, planes, missiles, and facilities—are durable, and only a small proportion of these assets are acquired in a single year. Some adjustments to military expenditure are needed.

A major objective of this study is the development of an index for determining the size of military forces in monetary terms that makes the necessary adjustments. A. S. Becker introduced this index of military output, called military force potential (MF), as "a measure based only on the national capability to apply physical force against external opponents—that is, without any reference to the external context."⁴ The index depends on the stock of durable military assets—the military capital stock—as well as the men and materials needed to operate and maintain these assets. As the external context does not vary, military force potential does not depend on the capabilities of an adversary. However, changes in relative capability can be compared using an index of relative military power (MP), which is also developed in this study.

The suggested monetary measure of military force potential is actually an imputed expenditure level equal to the economic cost of supporting the order of battle in a given period. Although the relationship between the imputed expenditure level and annual military expenditure is rigorously developed in Sec. III, it is appropriate to mention some aspects of this relationship.

The imputed cost of supporting current forces is a legitimate measure of military force potential because the cost of military output and the output produced are directly related to each other whenever there are unchanging prices of military assets. As military force potential increases, so also does the cost of achieving the higher level of capability. This cost includes the operating expenditure as well as the cost of the capital services yielded by the military equipment and facilities. A portion of the cost of military output is included in military expenditure—operating expenditure and replacement investment. Replacement investment is part of the cost of capital services in this analysis because it equals the depreciated military capital.

Two other parts of the cost of military capital are not included in calculated military expenditure, but they should be included in military force potential. These are the interest charge needed to reflect the opportunity cost of capital and the capital loss resulting from changes in the acquisition price of military assets. They are part of the economic cost of defense during any time period.

Two cost elements are also part of military expenditure but should not be included in a military force potential index. These are RDT&E and net investment, both of which are directed toward achieving future increases in capability rather than during the given period. Net investment equals the net additional capital acquired during the period and is equal to total (or gross) investment minus replacement investment. In summary, the military force potential index differs from military expenditure because MF includes the interest charge on military capital and capital losses but excludes RDT&E and net investment.

To discuss the relationship between military expenditure and military force potential properly, it is necessary first to develop some principles of military capital. This is accomplished in Sec. II. Section III rigorously explores the relationship between ME and MF and substanti-

⁴A. S. Becker, "The Meaning and Measure of Soviet Military Expenditures," in *Soviet Economy in a Time of Change. A Compendium of Papers Submitted to the Joint Economic Committee, Congress of the United States, Volume 1*, October 10, 1979.

ates the discussion provided above. Also included in Sec. III are some hypothetical calculations of the level of MF and its growth rate for the Soviet Union during the period 1967-1977. In Sec. IV there is a discussion of an index of relative military power (MP), which equals the ratio of the U.S. to the Soviet military force potential.

II. THE MILITARY CAPITAL STOCK¹

The military capital stock is an aggregate measure of all equipment, facilities, and supply inventories that are part of a military establishment at some time.² These assets are durable goods that are not totally consumed during their acquisition period. The durable nature of equipment and facilities introduces a number of complications not present in the valuation of a military input such as POL that is consumed when utilized. The military value during some period of an additional unit of POL can be measured by the acquisition price, which equals the amount the military is willing to pay for an additional unit of this material. Similarly, although there are complications associated with military manpower that are discussed in Sec. III below, the average cost of manpower is probably a reasonable measure of value. However, the acquisition price of a durable asset is not a measure of the value of the service it provides during any period. Rather, it is the value of the services provided by the asset over its entire life. During the life of such an asset, alternative uses of the resources are being forgone, the acquisition price may change, and the quality level of new acquisitions can vary. Also, the output level achieved by an asset may decline over time, and this rate of decline may be influenced by maintenance activities. All of these factors should be taken into account when one measures the value of the services provided by a durable asset during a particular period.

In this part of the analysis, I describe how the durable defense assets can be meaningfully aggregated. Although the capital stock measure obtained can be interpreted as the present value of benefits yielded by the stock *over its remaining life*, the primary reason why military capital is a measure of interest is because of its contribution *during some specified time period*. The value of capital services is obtained by weighting each of the capital types by its implicit user cost each period. The user cost is likely to vary across assets because of variations across assets of depreciation and capital loss rates, and also because of differences in maintenance outlay rates.

To convey the essential features of military capital, I illustrate the methodology using two basic types of equipment, tanks and planes. The principles developed carry over to an actual capital stock determination in which there are many equipment and facility types. A companion study discusses the principles of military capital valuation at a more technical level.³

THE MILITARY CAPITAL STOCK OF AN ASSET CLASS

Suppose there are two types of military equipment, tanks and planes. Although it is possible to develop measures of military capital that account for changes in the performance

¹A military capital stock for the United States has been developed by the Department of Commerce and presented in John C. Musgrave, "Government-Owned Fixed Capital in the United States, 1925-1979," *Survey of Current Business*, March 1980, pp. 32-43. For a discussion of the uses of an estimated military capital stock measure in the United States, see R. V. L. Cooper and C. R. Roll, Jr., *The Allocation of Military Resources: Implications for Capital Labor Substitution*, The Rand Corporation, P-5036-1, May 1974. Also, Robert Shishko has estimated a military capital stock for the *Bundeswehr*, which is reported in *The Allocation of Defense Resources: Capital and Labor Substitution in the Bundeswehr*, The Rand Corporation, R-2142-MRAL/ARPA, forthcoming.

²Spares and ordnance are included in the military capital stock. However POL is considered a nondurable good and would not be included. Although ordnance is certainly nondurable when expended, it does provide military services over time when in inventory. The services derive from the potential military capability it represents.

³G. G. Hildebrandt, *The Economics of Military Capital*, The Rand Corporation, R-2665-AF, August 1980.

characteristics of an equipment type, for simplicity we assume that all tanks and all planes are identical.⁴

To develop a measure of the military capital stock K , and also the value of the services Z provided by this stock during a given period, it is helpful first to develop monetary measures of the stock of tank capital K_1 and the stock of plane capital K_2 . One can then obtain K and Z by appropriate aggregations of these two subaggregate measures. As the derivations of K_1 and K_2 are conceptually identical, we need focus only on measuring tank capital. An analogous procedure applies for planes.

During current period t , the acquisition price of a tank is $P_{1,t}$. This price is the real cost of a tank during that time period; the monetary effect of general inflation has been purged from the data. The price $P_{1,t}$ depends on time because of technological change in the tank producing industry. This technological change is assumed to lower the real cost of producing a tank each period; the rate of decline is γ_1 .

It is appropriate for the military to acquire additional tanks each period until the monetary value of an additional tank equals the acquisition price. Therefore, the acquisition price equals the discounted value of the military benefits provided by an additional tank over its life, where the benefits each period are discounted to the current period using the social discount rate r .

Although the acquisition price of a tank is a measure of value, this yardstick is changing over time as the price declines. In order to compare measures of tank capital over time, it is necessary to use an unchanging measuring rod. Therefore, the acquisition price in some base period $P_{1,b}$ is used to measure the military benefits obtained from a new tank during its lifetime.

As a tank ages its value is assumed to depreciate each period at a constant rate δ_1 .⁵ A tank acquired in period t is assumed to become part of the active inventory in $t + 1$. In $t + 1$ it yields the full benefits of a new tank; during $t + 2$ its output has declined to a proportion $1 - \delta_1$ of this level. Because the rate of decline remains constant over time, in $t + 3$ its output has declined to $(1 - \delta_1)^2$ the original level. Therefore, a tank acquired during a period v before t yields an output during current period t that is a proportion $(1 - \delta_1)^{t-1-v}$ of a new tank's output. If $N_{1,v}$ tanks are acquired at v , then these tanks yield a military output during t that is equivalent to $N_{1,v}(1 - \delta_1)^{t-1-v}$ new tanks. The monetary value of these tanks at t would be $P_{1,b}N_{1,v}(1 - \delta_1)^{t-1-v}$. This is the product of the monetary value of a new tank and the number of new tanks that are equivalent to the $N_{1,v}$ old tanks.

Suppose we know that the current value of tank capital of some earlier period $t = 0$ equals $K_{1,0}(1 - \delta_1)^t$. The depreciation of this capital has occurred for t periods. The aggregate measure of tank capital is then obtained by adding to this quantity the current value of all acquisitions obtained subsequent to the early period through period $t - 1$. This aggregation yields

$$K_{1,t} = \sum_{v=0}^{t-1} P_{1,b} N_{1,v} (1 - \delta_1)^{t-1-v} + K_{1,0} (1 - \delta_1)^t \quad (2.1)$$

The summation stops at $t - 1$ because the $N_{1,t}$ acquisitions during period t are not part of the active inventory until $t + 1$.

As an aid to understanding the process of capital creation, it is helpful to relate the capital stock at $t + 1$ to the value at t . The new acquisitions during t have a value of $P_{1,b}N_{1,t}$ at $t + 1$; they are part of $K_{1,t+1}$. However, because of depreciation, only $(1 - \delta_1)K_{1,t}$ tank capital

⁴Ibid., for a discussion of how changes in quality can be handled.

⁵If δ_1 is not constant, the analysis is substantially more complex. For a discussion of alternative assumptions that might be made, see *The Economics of Military Capital*.

remains from the period t stock. Therefore, the value of the capital stock in period $t + 1$ would be

$$K_{1,t+1} = P_{1,b}N_{1,t} + (1 - \delta_1)K_{1,t}. \quad (2.2)$$

This expression is really a special case of Eq. (2.1) for the situation in which the early period is a single period before the current period. Equation (2.2) can be rewritten as

$$K_{1,t+1} - K_{1,t} = P_{1,b}N_{1,t} - \delta_1 K_{1,t}. \quad (2.3)$$

The change in the value of tank capital equals the value of new acquisitions less the value of capital that depreciated during the period. The value of new acquisitions is called the *gross tank investment*, $I_{1,t} = P_{1,b}N_{1,t}$. This value term is frequently simply called the tank investment. The change in the capital stock is called the *net tank investment*, $I_{1N,t} = K_{1,t+1} - K_{1,t}$. Using Eq. (2.3), the gross investment can be divided into the net investment plus the replacement of the depreciated capital. This latter amount is called the replacement investment, $I_{1R,t} = \delta_1 K_{1,t}$.

$$I_{1,t} = I_{1N,t} + I_{1R,t}. \quad (2.4)$$

Although this equality between gross investment and net plus replacement investment is a definitional relationship, replacement investment equals the value of depreciated capital only when the depreciation rate of this single asset type is constant.⁶ Given the definition of net investment, it is clear that an equivalent representation of Eq. (2.1) is

$$K_{1,t} = \sum_{v=0}^{t-1} I_{1N,v} + K_{1,0}. \quad (2.5)$$

The military capital stock for tanks is computed by adding the net investment each period to the value of the capital stock in the initial period.

TOTAL MILITARY CAPITAL STOCK

The stock of plane capital is also computed using equations either of the form (2.1) or (2.5) and the total military capital stock in any period would be the sum of the two types of capital:

$$K_t = K_{1,t} + K_{2,t}. \quad (2.6)$$

This simple summation is valid because the last dollar spent on both a tank and a plane must yield equal military benefits over the life of each asset.

Total gross investment (or simply total investment) I_t is the sum of the gross investment in tanks plus the gross investment in planes. This total investment in t is part of the total capital stock in $t + 1$. However, only $(1 - \delta_1)K_{1,t} + (1 - \delta_2)K_{2,t}$ of the period t stock remains in $t + 1$. If an aggregate depreciation rate is defined by

$$\delta_t = \frac{\delta_1 K_{1,t} + \delta_2 K_{2,t}}{K_t}, \quad (2.7)$$

⁶This result is discussed by D. Jorgenson and Z. Griliches in "Issues in Growth Accounting: A Reply to Edward F. Dennison," *Survey of Current Business*, May 1972, p. 86.

then the change in total capital would be computed by

$$K_{t+1} - K_t = I_t - \delta_t K_t. \quad (2.8)$$

This expression is similar to Eq. (2.3). However, the aggregate depreciation rate can vary with time even if the individual depreciation rates are constant. This aggregate depreciation rate would not be constant unless both types of military capital happen to be growing at the same rate.⁷

THE VALUE OF CAPITAL SERVICES

Even though the total military capital stock equals the value of the aggregate capital stock at t , this aggregation fails to account for differences in the military productivity of a dollar's worth of tanks versus a dollar's worth of planes during the given period. What K_t represents is the aggregate value of the stock of military capital that derives from the services it provides over its remaining life. One may be primarily interested, however, in measuring the contribution of military capital to military capability in a given period—that is, the value of the services provided during that period.

If B_i , $i = 1, 2$, represents the value during the period of an additional dollar's worth of tank capital or plane capital, then Z_t , the monetary value of the military capital services during the period, would be computed as a weighted average of the tank capital and plane capital with the weights equal to B_1 and B_2 :

$$Z_t = B_1 K_{1,t} + B_2 K_{2,t}. \quad (2.9)$$

THE USER COST OF MILITARY CAPITAL

The value measures B_i can be estimated. Each period, it is appropriate for the military to acquire additional tanks or planes until the value of the services provided during the first period of use equals the cost of failing to postpone the acquisition one period. This cost is called the user cost of capital and is designated C_i , $i = 1$ for tanks and 2 for planes.

Because $B_i = C_i$, $i = 1, 2$, whenever the resources are allocated efficiently, Eq. (2.9) can be rewritten

$$Z_t = C_1 K_{1,t} + C_2 K_{2,t}. \quad (2.10)$$

When the capital types are weighted by the user cost factor, Z_t can be interpreted as the cost of the services provided by the capital stock during period t ; because $B_i = C_i$ it is legitimate to use this cost to measure value.

The user cost of a military asset has several components. Interest costs, depreciation, capital losses, and maintenance outlays occur because of the failure to postpone the acquisition until the next period.

Interest costs are incurred because the resources used to produce the asset can earn an interest return per dollar equal to the social discount rate r elsewhere in the economy. There

⁷For total replacement investment to equal total depreciation the aggregate depreciation rates are not necessarily constant, but the individual depreciation rates must be.

is a depreciation cost of δ_1 per additional dollar spent because of the extra period's deterioration. The *remaining benefits* for the asset are δ_1 percent lower than would be obtained if the acquisition was postponed. There is a capital loss of γ_1 on the last dollar acquired because the acquisition price is assumed to decline at that rate. By spending an additional dollar on an asset in some period, the opportunity to take advantage of the next period's lower price is forgone. Finally, there is a cost associated with the maintenance outlays. If each dollar's worth of an asset requires maintenance outlays of m_1 per period, an expenditure of m_1 could be avoided by postponing the expenditure of the last dollar. Therefore, the user cost of an additional dollar's worth of the asset would be the sum of the four cost factors:

$$C_i = r + \delta_1 + \gamma_1 + m_1, \quad i = 1, 2. \quad (2.11)$$

As each of these cost factors is constant under the assumptions of this analysis, the user cost rate would also be constant for each type of equipment. However, three of the cost factors would be specific to a type of military capital so that the current benefits from each dollar's worth of different capital would not, in general, be the same.

An aggregate user cost factor C_t can be computed in a manner similar to the aggregate depreciation rate of Eq. (2.7):

$$C_t = \frac{C_1 K_{1,t} + C_2 K_{2,t}}{K_t} \quad (2.12)$$

By assumption the C_i are constant. However, the aggregate user cost factor depends on time unless both K_1 and K_2 are growing at the same rate.

With Eq. (2.12) and its definition of the aggregate user cost factor, the aggregate value of military capital services in the current period is written:

$$Z_t = C_t K_t. \quad (2.13)$$

However, to compute Z_t using either Eq. (2.10) or Eq. (2.13) one needs to know the implicit user cost rates for both tanks and planes. These rates are each the sum of four factors that must be estimated.

ESTIMATING THE USER COST FACTORS

The Interest Cost r

This cost factor is likely to be invariant across the different types of military capital. It equals the social discount rate and might be estimated using the net productivity of civilian capital. In the United States, the Office of Management and Budget has specified this rate to be 10 percent.⁸ For the Soviet Union an interest charge on capital of 12 percent has been used in several studies.⁹

⁸OMB Circular No. A-94, March 27, 1972.

⁹For example, CIA, *USSR: Gross National Product Accounts*, A(ER)75-76, November 1975, p. 80.

The Depreciation Rate δ_i

If one assumes that maintenance activity occurs so as to maintain the original level of performance embodied in the equipment, the depreciation rate would equal the scrappage rate,¹⁰ which can be estimated if survey information is available each period of the constant dollar replacement cost of all members of an asset class.

Capital Loss Rate γ_i

Capital losses occur when the cost of producing a particular type of equipment declines over time as a result of technological change. There is an effective capital loss on existing equipment. The parameter γ_i , which is the percentage decline in price each period, can be estimated using statistical techniques.

Maintenance Expenditure Rate m_i

The maintenance expenditure rate m_i can be obtained by dividing total maintenance expenditures during a period in support of asset i by the value of that asset's capital stock. This analysis assumes that there is a constant relationship between these two quantities.

After the components of the user cost rate for each type of military capital have been computed, Eq. (2.10) can be used to compute the total value of military capital services during any given time period.

The next section describes an important use of the value of military capital services. It is an important component of the military force potential index that measures military output in a given period. For ease in understanding the military force potential index, the aggregate user cost rate computed using Eq. (2.12) is used in deriving this military output index. However, different military capital types would have differing values during any given period; the individual cost rates that equal these military values would vary with the military equipment and facility type.

¹⁰Once again, the depreciation rate is assumed not to vary over time. The scrappage rate will eventually approach a constant for a particular asset type as long as acquisitions are growing at a constant rate. This convergence theorem is discussed in M. S. Feldstein and M. Rothschild, "Towards an Economic Theory of Replacement Investment," *Econometrica*, May 1974, pp. 393-423. More general maintenance expenditure patterns are discussed in *The Economics of Military Capital*.

III. MILITARY EXPENDITURE AND FORCE POTENTIAL

Military expenditure, as a flow indicator, fails to capture the full potential of all military assets, many of which were acquired before the given period. Rather, it is a measure of the capacity of the defense sector to produce goods and services during the period. Although such a measure of sector size is an interesting summary statistic, the problem at hand is one of designing an index of military output that reflects the potential of all personnel, material, equipment facilities, and supply inventories to apply force during a given period. The entire stock of military capital clearly must play an important role in such a measure, and only a small portion of this stock is likely to have been acquired in a given period.

Although the stock of military capital is not the only contributor of military force potential, a significant degree of understanding of the relationship between military expenditure and military force potential can be obtained if one considers the relationship between military investment and military capital. In the Soviet Union, investment, measured in rubles, constitutes about 50 percent of military expenditure.¹ It is an important part of military expenditure just as military capital must be an important part of any military force potential index.

The relationship between net investment and the military capital stock is most illuminating. As indicated by the aggregate version of Eq. (2.4), net investment is defined as the difference between the gross (or total) investment and the investment that replaces the depreciated capital (the replacement investment). It equals the additions to the military capital stock. *The military capital stock must be increasing over time if net investment remains positive.* Therefore, even if net investment is constant over time, the capital stock must be growing. Another very useful relationship follows from the definition: *If the net investment to capital stock ratio is greater than the growth rate of net investment, the capital stock must be growing faster than net investment.* There is an accelerator principle at work in capital stock formation, and an interesting question is the extent to which this principle might be operating in the Soviet Union.

MILITARY EXPENDITURE

The purpose of a military force potential index is to *quantitatively* identify military output and its rate of growth. It is helpful to begin first with military expenditure, which equals the RDT&E, (Gross) Investment and Operating outlays during a particular year:

$$ME = RDT\&E + INVESTMENT + OPERATING. \quad (3.1)$$

As indicated above, investment expenditure consists of net investment I_N , which equals the addition to the capital stock plus replacement investment I_R . The replacement investment is that part of gross investment replacing the depreciated capital, δK , where δ is the depreciation rate. Thus,

$$INVESTMENT = I_N + \delta K. \quad (3.2)$$

¹CIA, *Estimated Soviet Defense Spending: Trends and Prospects*, p. ii.

Operating expenditures include expenditures on manpower, WL , where W is the average cost per individual and L equals the number of personnel in the defense establishment; expenditures on the material needed to operate the capital stock, $P_G G$, where P_G is the unit price and G is the quantity of material inputs; and expenditures on maintenance activities, $P_M M$, where P_M is the per unit price of maintenance and M equals the level of maintenance activity.

$$\text{OPERATING} = WL + P_G G + P_M M. \quad (3.3)$$

Equations (3.2) and (3.3) can be used to substitute for Investment and Operating in Eq. (3.1), yielding

$$ME = RDT\&E + I_N + \delta K + WL + P_G G + P_M M. \quad (3.4)$$

The development of a relationship between this expression and military force potential is one of the primary goals of this study. Before this comparison can be made, it is necessary to identify an appropriate force potential index.

A MILITARY FORCE POTENTIAL INDEX

Any legitimate index of military force potential must reflect the level of military output that could be produced during some specified period by the manpower, capital, and material of the defense establishment. The assumption made is that all manpower in the defense establishment, both military and civilian, contributes to military force potential. Even the manpower in training during a given period influences the level of deterrence achieved by the military forces; they would be available for many operational uses during an emergency. Because the stock of reserve forces also influences deterrence, this stock can be viewed as contributing to the achievement of force potential.

The level of output produced by these current forces is determined by a military production function of the form

$$MF = f(L, K, G). \quad (3.5)$$

This function describes how the military manpower, capital, and material can be substituted for each other without changing military output. The military production function is assumed to exhibit constant returns to scale, which means that if manpower, capital, and material are increased by some proportion, so is military force potential. This seems to be the most reasonable assumption to make for a force potential index: If all the tanks, planes, missiles, etc. and the personnel, material, and facilities are increased by, say, 25 percent, the potential to apply force also increases by 25 percent.²

The essence of identifying military force potential quantitatively is determining a method of properly measuring MF . The assumption of cost-minimizing behavior provides the basis by insuring that the last dollar spent on each input yields the same extra output. The marginal product-to-factor-price ratio should be the same for labor, capital, and material:

$$\frac{\partial f / \partial L}{W} = \frac{\partial f / \partial K}{C} = \frac{\partial f / \partial G}{P_G}, \quad (3.6)$$

²There is additional discussion of the constant returns to scale assumption later in this section.

where $\partial f/\partial L$, $\partial f/\partial K$, and $\partial f/\partial G$ are the marginal products of labor, capital, and material respectively, and C is the user cost of military capital.

As indicated above, W is the average cost of manpower. This cost includes pay and allowances as well as training costs. It might be argued that it is appropriate to amortize training costs to obtain the value of an additional unit of labor. Because there are likely to be training costs at the beginning of active service, the military pay and allowances may be less than military productivity during at least part of one's military career. However, the diverse amortization possibilities can make such a procedure analytically and empirically unmanageable. It is probably best to treat training costs as part of the variable costs of labor during the period. Similarly, the average manpower cost of the reserves is probably the "appropriate" measure of value. Overall, the average cost of manpower is probably a reasonable estimate of the military value of an additional "average" unit of military labor.

Equality (3.6), the well-known tangency solution, is isocost-isoquant analysis, which is illustrated in Fig. 1 for several levels of military output at some specified level of material input G . The material input is held constant to indicate efficient solutions graphically.

If the slope of the budget line that equals the wage-user cost ratio W/C remains constant, increases in military output level must be directly related to increases in the imputed expenditure level that is associated with the budget line. Because this level is an increasing function of military force, it can be used to measure military output. This imputed expenditure level

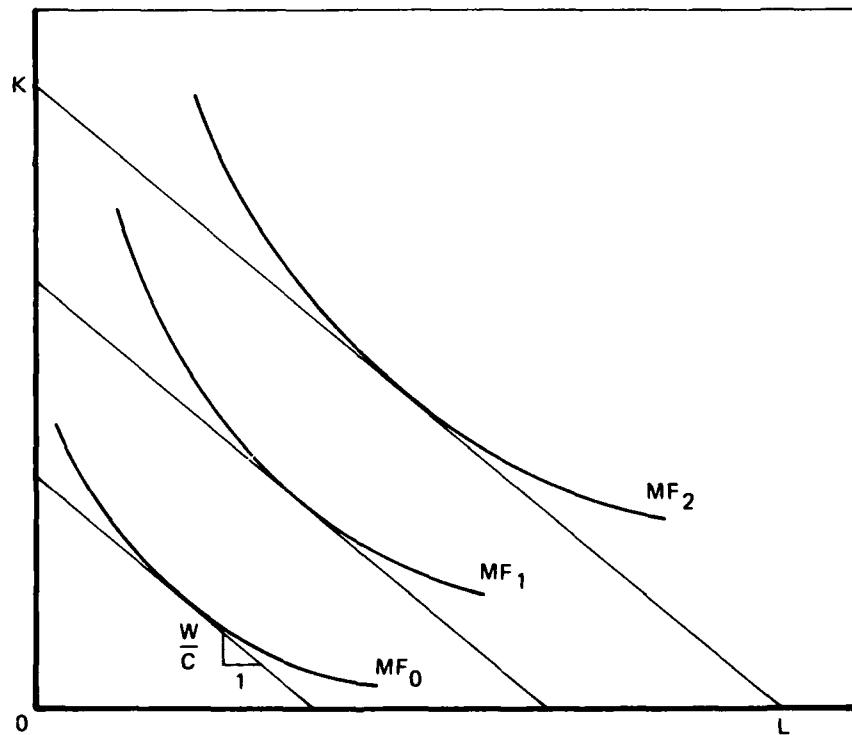


Fig. 1—Isocost-isoquant analysis

actually measures the value of the resources (the military inputs) used to produce force potential (the military output). If it increases by some proportion, military output increases by a like proportion. Thus, measuring force potential is somewhat akin to measuring national output. National output can be measured using either input costs or product (or output) prices, and the two measures are necessarily equal.

There is a similar implied equality in the computation of force potential. The expenditure on the tanks, troops, munitions, and other military outputs is equal to the expenditure on the inputs—labor, capital, and material—that produce these outputs. Therefore, comparing percentage changes in military force potential is analogous to comparing percentage changes in national output. For both measures, the percentage change in expenditure is used. Although neither measure requires the constant returns to scale assumption, this assumption for the force potential index *guarantees* that percentage changes are comparable. Without this assumption one may be unwilling to compare percentage changes in force potential just as one may be unwilling to compare percentage changes in national output.

To measure military force potential, then, it is appropriate to compute

$$MF = WL + CK + P_G G. \quad (3.7)$$

Of course, in an actual situation, the price ratios may not remain constant. However, if the ratios are held constant at some base level, and L, K, and G are the levels of manpower, capital, and material selected, then Eq. (3.7) can still be used to approximate military output. Laspeyres and Paasche index number theory can be used to bound the approximation range.³

In order to operationalize Eq. (3.7) it is necessary to determine the military capital stock and its user cost rate. Section II of this study showed that the user cost of each unit of military capital equals the sum of the interest charge r on each unit of military capital, the depreciation rate δ of military capital, the capital loss rate γ from reductions in acquisition price, and the maintenance expenditure m generated by each unit of capital. Therefore, the imputed rental rate would be computed as

$$C = r + \delta + \gamma + m. \quad (3.8)$$

Substituting this relation in Eq. (3.7) yields

$$MF = WL + rK + \delta K + \gamma K + mK + P_G G, \quad (3.9)$$

where it may be recalled that the depreciated capital δK equals replacement investment.

FORCE POTENTIAL VERSUS EXPENDITURE

As military expenditure is carefully estimated, it may be that the easiest approach to measuring force potential is to work directly from expenditure information. ME and MF can be compared by examining Eqs. (3.4) and (3.9). Maintenance activity m is assumed to be a fixed proportion of the capital stock, and the expenditure per unit of additional capital equals m . Both of the equations contain the expenditure on labor, replacement investment, and operations and

³There is a discussion of the upper and lower bound of *relative* military output in R. E. Franck and G. G. Hildebrandt, *The Size and the Burden of Soviet Defense: Implications of Inter-Nation Comparability*, USAFA-TN-79-6, August 1979, United States Air Force Academy, Colorado.

maintenance. Because there are common elements, these equations can identify the relationship between force potential and military expenditure.

$$MF = ME + rK + \gamma K - I_N - RDT\&E. \quad (3.10)$$

Military force potential, therefore, equals expenditure plus the interest charge on the capital stock and the capital losses minus both net investment (the change in military capital) and RDT&E.⁴ Equation (3.10) has a straightforward explanation. An index of military force potential must account for the services provided by the existing capital stock. With the exception of the interest charge and the capital losses, military expenditure does account for these services because it includes replacement investment and the maintenance expenditure. However, military expenditure includes net investment, the change in military capital during the given period. Although this expenditure contributes to future effectiveness, it does not contribute to the level of MF in the given period and must be subtracted from ME. Similarly, RDT&E must be subtracted. This expenditure affects the quality level of subsequent additions to the capital stock but does not influence military output in the given period. RDT&E is a cost incurred in a given period in order to reduce the procurement cost of higher quality equipment in some subsequent period. One special case of this occurs when RDT&E is like a set-up charge that must be incurred for a new system to be produced. Such a fixed cost would not be a marginal expenditure on the L, K, and G inputs that produce military output, and, as indicated by Eq. (3.7), the military inputs are properly weighted by their incremental cost.⁵

Perhaps the most meaningful representation of the relationship between ME and MF is in terms of percentage changes. To illustrate the relationship, suppose that military expenditure and its constituent parts are all growing at a rate g . Then, using Eq. (3.10) one can derive⁶

$$\frac{\Delta MF}{MF} = g + \frac{rK}{MF} \left(I_N - K - g \right). \quad (3.11)$$

where $\Delta MF / MF$ equals the growth rate of military output and I_N / K equals the growth rate of the military capital stock—the net investment to capital stock ratio. Military force potential is growing faster than military expenditure whenever the capital stock is growing faster than net investment. This result can be stated slightly differently to provide a straightforward empirical test: Suppose military expenditure and its constituent parts are all growing at a constant rate. Then, if the net investment to capital stock ratio is greater than the constant growth rate, military force potential must be growing faster than military expenditure. One can also show that if I_N / K is greater than g , then as time passes the growth rate of capital will decrease until its growth rate eventually equals g .

⁴The adjustments to military expenditure to calculate military force potential might be likened to the adjustments made to Gross National Product (GNP) to compute a Measure of Economic Welfare (MEW). Just as GNP has limitations for measuring national welfare, military expenditure has limitations for measuring military output. For a discussion of the adjustments to GNP that are made see W. Nordhaus and J. Tobin, "Is Growth Obsolete?" in *Fiftieth Anniversary Colloquium V*, National Bureau of Economic Research, Columbia University Press, New York, 1972.

⁵The relationship between RDT&E and the military capital stock is discussed at greater length in Hildebrandt, *The Economics of Military Capital*.

⁶First compute the first difference of Eq. (3.10) with respect to time to obtain $\Delta MF = \Delta ME + r\Delta I_N - \Delta I_N - \Delta RDT\&E$. As ME, I_N , and RDT&E are growing at rate g , this can be written as $\Delta MF = g(ME + rK - I_N - RDT\&E) + rI_N - grK$, where grK has been added and subtracted from the expression. Recognizing that the term in parentheses is MF, after dividing through by MF one obtains Eq. (3.11).

COMPUTATION OF SOVIET MF GROWTH

In order to better understand some of the computational issues associated with the military force potential index, it is helpful to calculate values of this indicator using a combination of estimated and hypothetical data. The calculations are intended to be only illustrative, but they are helpful for bringing into focus various aspects of the relationship between military force potential and military expenditure. For example, it is important to understand the nature of the information needed to determine whether force potential has been growing faster than expenditure in the Soviet Union.

It is evident from Eq. (3.10) that accurate estimates are needed of military expenditure, net investment, RDT&E, the military capital stock, the interest rate on military capital, and the capital loss rate in order to make an empirical analysis of the relationship between force potential and military expenditure. Because the available Soviet data are measured in 1970 prices, it is necessary to ignore capital losses in the computations. However, the effect on the calculation is likely to be small.⁷

As indicated above, an interest rate of 12 percent is frequently used in Soviet studies. Estimates of military expenditure and RDT&E have been provided by the CIA.⁸ Therefore, if a carefully estimated military capital stock and associated net investment series for the Soviet Union were available, it would be possible to examine the relationship between force potential and military expenditure. Unfortunately, there is no military capital stock series readily available for the Soviet Union, and it is necessary to identify hypothetical values of both the Soviet military capital stock and net investment in order to calculate values for military force potential. Although there is great uncertainty associated with the values obtained, the illustrations may point to the importance of carefully estimating a military capital stock series for the Soviet Union.

The CIA's estimates of Soviet military expenditure and its component parts are made for 1967-1977. Therefore, it is convenient to compute illustrative values for military force potential for selected years during that period. The years 1967, 1972, and 1977 seem to be appropriate, and it is necessary to identify values for military expenditure, RDT&E, net investment, and the military capital stock for those years.

Military Expenditure

The CIA developed two estimates of the Soviet defense spending, in 1970 rubles, for the period 1967-1977. One estimate is based on the U.S. definition of defense spending; the second is based on the broader Soviet view of military spending. The estimates of Soviet defense spending are more accurate using the U.S. definition. Also, a measure of military output that uses the U.S. terms of reference is more understandable by U.S. policymakers. Therefore, the narrower U.S. definition of defense spending is used in the computation of Soviet military output. Under this definition, Soviet defense spending is estimated to have grown at an annual

⁷*Price Changes of Defense Purchases of the United States*, U.S. Department of Commerce Bureau of Economic Analysis, March 1979, reports that the implicit price index for U.S. durable defense goods rose from a base level of 100 in calendar year 1972 to 140.4 during the fourth quarter of 1977. At the same time the implicit price deflator for private gross national product rose to 143.1. Therefore, the real cost of defense durable goods did not change significantly in the United States. In the Soviet Union, relative prices may have been moving toward those that apply in the United States, so the real cost of durable goods has been declining. However, the reduction in real cost each period is probably small. To estimate the capital loss rate it would be necessary to have price indexes for both Soviet military investment goods and nonddefense goods.

⁸CIA, *Estimated Defense Spending*.

rate of 4 to 5 percent during 1967-1977; there is reasonable confidence that the actual range is neither significantly higher nor lower. The CIA has also identified this range as the long-term growth trend of Soviet defense spending, and it is expected to persist into the 1980s.⁹

In 1967, the level of Soviet defense spending in 1970 rubles is estimated to have been 35-40 billion rubles; by 1977 it had risen to 53-58 billion rubles. Using the mid-points of these defense spending ranges, the annual growth rate of Soviet defense spending equals 4.0 percent during the period. In 1967, the mid-point of the CIA's range of estimates is about 46.2 billion rubles.¹⁰ Therefore, the annual growth rate is about 4.3 percent during the first half of the ten-year period; between 1972 and 1977 the rate declines to about 3.7 percent. The variation in growth seems to result, in large part, from the procurement cycles of weapon systems.

RDT&E

RDT&E is the fastest growing resource category; it is also the category about which the CIA has the lowest confidence in their estimates. The share of defense expenditures going to RDT&E "increased from less than one-fifth in 1967 to nearly one-fourth in 1977."¹¹ In the computation of military force potential, it is convenient to assume that 20 percent of military expenditure went to RDT&E in 1967—about 7.5 billion rubles—and 25 percent in 1977—about 13.9 billion rubles. The annual growth rate for RDT&E implied by these spending levels is 6.4 percent. This growth rate is used to estimate a 1972 value for RDT&E equal to 10.2 billion rubles.

Net Investment

Net investment I_N equals the net increase in military equipment and structures during a given period. It is computed by deducting from gross investment the value of replacement investment. During the 1967-1977 period, gross (or total) investment I is estimated to have averaged slightly more than 50 percent of defense spending; more than 90 percent of this investment spending was for the procurement of military equipment.¹² However, values of net investment have not been indicated by the CIA, and several assumptions are needed in order to estimate this variable.

Suppose that gross investment has been increasing at a long-term annual growth rate of 4 percent and that this investment is maintained at its original capability level until it is withdrawn from the inventory. If the service life of the investment is known to be s years, it is possible to solve for the part of gross investment that replaces the investment made s years earlier.

$$I_{t-s} = I_t / (1.04)^s \quad (3.12)$$

⁹Ibid., pp. 1, 11. The Soviet definition of defense spending includes expenditures for "internal security troops, certain civil defense activities, military stockpiling, foreign military assistance, and space programs that are operated by the military in the USSR but by the National Aeronautics and Space Administration in the United States." The current outlay for military retirement is included in military expenditure. However, as indicated in *Allocation of Resources in the Soviet Union and China—1978*, p. 71, military retirement is about 1 percent of military expenditure. In principle, the present value of future retirement outlays resulting from current expenditure on manpower should be included in estimated military expenditure. Although this is not included in military expenditure, it is also likely to be fairly small.

¹⁰Ibid., p. 1.

¹¹Ibid., p. 2.

¹²Ibid.

where I_t and I_{t-s} equal the level of gross investment at time t and $t-s$ respectively. The gross investment at t has been deflated by $(1.04)^s$ to reduce it to the level of gross investment undertaken s years earlier. This earlier investment is replaced at t . When this computed level of replacement investment is subtracted from gross investment, one obtains the relationship between net and gross investment that is assumed to apply each period:

$$I_{N,t} = I_t - I_t/(1.04)^s. \quad (3.13)$$

Therefore, knowledge of the growth rate, the service life, and the level of gross investment enables one to compute net investment.

There are several problems with this approach. One problem occurs if there is a major disruption in a long-term trend, such as occurred during World War II. After such a disruption, it may take some time for the relationship to be reestablished, even if the growth rate of gross investment remains at some constant level. However, it may not be unreasonable to assume that the Soviets had reestablished the long-term relationship between net and gross investment by 1967. Another problem is that military equipment and structures actually have a variety of service lives. The average service life would depend on the composition of the capital stock, and this composition may be changing over time. An additional problem is that the service lives of Soviet military equipment and structures are not readily available. In spite of these problems, this method is used to "estimate" the relationship between net and gross investment for the Soviet military establishment.

As a first approximation, suppose that the service lives of equipment and structures in the U.S. military establishment also apply to the Soviet Union. Then, the composition of Soviet military expenditure by service can be used to identify an average service life for Soviet military equipment. Using the composition of investment for 1967, one obtains an average service life for Soviet military equipment of 18.6 years. Equation (3.12) is then used to determine that about 52 percent of the gross investment in military equipment equals an addition to the military capital stock.¹³

The U.S. service life for nonresidential military structures is estimated to be 50 years.¹⁴ Therefore, about 86 percent of the structure investment is an addition to the military capital stock. Using the proportions of Soviet defense spending devoted to procurement as 90 percent and to production as 10 percent, one can compute the overall proportion of gross investment that equals an addition to the military capital stock as about 55 percent. With gross investment assumed to equal 50 percent of military expenditure, the computed levels of net military investment equal 10.4 billion rubles in 1967, 12.8 billion rubles in 1972, and 15.3 billion rubles in 1972.

The use of U.S. service lives for the Soviet military establishment is somewhat arbitrary, and it is appropriate to vary this assumption to determine how the computed levels of net investment and military force potential respond. This sensitivity analysis is accomplished below, but it fails to indicate a substantial change in the levels of computed force potential.

¹³Ibid., pp. 3-6, indicates the proportions of Soviet military spending for each service. With the exception of Strategic Rocket Forces and Command and Support, the proportions of service spending for investment are also indicated. It is assumed that 80 percent of Strategic Rocket forces spending and none of Command and Support spending were for investment. The following is also assumed: Strategic Rocket Forces investment was for missiles, National Defense Forces investment was for aircraft, Navy investment was for ships, Air Forces investment was for aircraft, and Ground Forces investment was for vehicles. In Musgrave, "Government-Owned Fixed Capital in the United States," p. 43, U.S. military service lives are assumed to be aircraft—12 years, missiles—10 years, ships—30 years, and vehicles—20 years.

¹⁴Ibid.

The Military Capital Stock

If a survey of the equipment and structures in the Soviet military establishment is available for each period, and if these durable military assets are maintained at their original capability level until the end of their service life, then one can use the aggregate replacement cost of the equipment and structures to estimate the military capital stock. Alternatively, a capital stock series can be estimated by identifying the current value of a base military capital stock to which one would add the current value of each subsequent period's gross investment.

Without either type of information it is necessary to make some strong assumptions to estimate military capital. The value in 1967 of all Soviet durable assets acquired before 1948 is assumed to be sufficiently small relative to the size of the 1967 capital stock to be ignored. The year 1948 is selected because between 1945 and that year, the Soviets demobilized their defense establishment; the level of spending in 1948 was slightly more than one-third the 1945 level.¹⁵

Given this assumption, a "high" estimate of military capital in 1967 would be the sum of all the gross investments that occurred between 1948 and 1966; it is assumed to take one period for investment to become absorbed into the capital stock. This approach assumes that none of the investment between 1948 and 1966 had depreciated by 1967. All investment during the period was still producing military output at the original capability level; the long-term relationship in which net investment equals .55 gross investment had not yet reestablished itself.

A "low" estimate of 1967 military capital can be obtained by assuming that the long-term net-gross investment relationship applies during the 1948-1966 time period, and the value of the military capital stock in 1948 is small relative to the current value of the capital stock in 1967.

Without additional information, it seems reasonable for "the" estimate of military capital to be the average of the high and the low estimate. The key to this approach is to estimate a gross investment series for 1948 through 1966. As indicated above, between 1967 and 1977 Soviet military investment is about 50 percent of military expenditure. If this relationship also applies during the earlier period, a gross investment series can be estimated as soon as a military expenditure series can be identified for this period.

It is assumed that Soviet military expenditure increased at a long-term annual real growth rate of 4 percent during 1955-1967. This permits one to start with the CIA estimate of defense spending in 1967 equal to 37.5 billion rubles, which is measured in 1970 rubles, and estimate the implied decline in defense spending for each previous year. For 1955, a level of spending equal to 23.4 billion rubles is computed.

For the period 1948-1955, Soviet defense spending in 1937 prices has been estimated by Abram Bergson.¹⁶ His estimate must be adjusted to 1970 prices. Beginning with the 1955 estimates indicated above, the growth rates associated with Bergson's defense spending estimates are used to identify levels of defense spending for 1948-1954 in 1970 prices. The resulting estimate for 1948 is 15.3 billion rubles, and the annual growth rate from 1948-1955 is about 6 percent.

Given the military expenditure series and the associated levels of gross investment, a high estimate of military capital for 1967 is 241.1 billion rubles. The low estimate obtained by

¹⁵See Abram Bergson, *The Real National Income of Soviet Russia Since 1928*, Harvard University Press, Cambridge, Massachusetts, 1961, p. 366.

¹⁶Ibid.

assuming that net investment is 55 percent of gross investment between 1948 and 1966 is 132.6 billion rubles. The average of these two estimates yields an estimate for military capital in 1967 of 186.9 billion rubles and indicates that 77 percent of the aggregate gross investment occurring from 1948 remained in the inventory in 1967.

Beginning in 1967 the computed military capital stock is assumed to be augmented each year by 55 percent of that year's gross investment. The resulting values of military capital and military net investment are summarized in Table 1. During the ten-year period, the average annual growth rate of the military capital stock equals 5.3 percent. The annual growth rate for net investment was equal to 4.0 percent during the period. The growth rate of net investment derives from the fact that it is assumed to be a fixed proportion of military expenditure during the period.

Table 1

CAPITAL STOCK AND NET INVESTMENT
(Billions of 1970 rubles)^a

Year	Military Capital Stock	Net Investment
1967	186.9	10.4
1968	197.3	11.2
1969	208.5	11.5
1970	219.9	11.7
1971	231.7	12.1
1972	243.8	12.8
1973	256.6	13.1
1974	269.7	13.8
1975	283.5	14.5
1976	298.0	14.8
1977	312.7	15.3

^aIf we assume that the correct price adjustment has been made for changes in quality when converting to 1970 rubles, then these series properly take into account the quality changes that might have occurred. If the price index does not take into account quality changes, then the data in Table 1 would underestimate the growth rate of the capital stock and net investment.

To place the capital stock figures of Table 1 in some perspective, dollar-ruble ratios can be applied to selected years. In 1970 Soviet investment expenditure measured in 1979 dollars was approximately \$38 billion. These expenditures in 1970 rubles were about 21.3 rubles.¹⁷ Therefore, a ruble-dollar ratio of about 1.78 applies for investment during 1970. If the difference between the composition of Soviet investment in 1970 and the composition of military capital stock for the selected years is ignored, then this ratio can be applied to the capital stock values of Table 1 to translate the estimates into dollar terms. In 1972, an estimate of the Soviet military capital stock in 1979 dollars is \$434.0 billion. In 1977, the estimate is \$556.6 billion.

¹⁷The dollar estimate is obtained from *Soviet and U.S. Defense Activities, 1970-79*, p. 6, Fig. 2. The ruble estimate is obtained by taking 50 percent of the military expenditure level of about 42.5 billion rubles indicated in *Estimated Soviet Defense Spending* on the graph of p. 1.

The years 1972 and 1977 are convenient because Table 7 of Sec. IV below shows that the U.S. military capital stock for those two years is \$509.4 billion and \$508.6 billion respectively.

Military Force Potential

Now that values of the relevant variables have been identified, it is possible to compute military force potential using Eq. (3.10). It is assumed that depreciation equals replacement investment.¹⁸ As indicated above, capital losses are ignored. Table 2 contains the values of the relevant variables and the computed levels of military force potential in the Soviet Union for 1967, 1972, and 1977. The interest charge on military capital equals the values of the military capital from Table 1 multiplied by a 12 percent interest rate.

Table 2

SOVIET MILITARY FORCE POTENTIAL ELEMENTS (Billions of 1970 rubles)

	1967	1972	1977
Military expenditure	37.5	46.2	55.5
RDT&E	7.5	10.2	13.5
Net investment	10.4	12.8	15.3
Interest charge on military capital	22.4	29.3	37.5
Military force potential	42.0	52.5	63.8

Over the ten-year period, calculated military force potential increased by almost 52 percent. Military expenditure increased 48 percent. Table 3 summarizes the annual growth rates for ME and MF for 1967-1972, 1972-1977, and for the entire ten-year period. As computed, Soviet military force potential was growing slightly faster than military expenditure. Of course, the uncertain nature of the capital stock, net investment, and RDT&E estimates prohibits any firm conclusions concerning whether Soviet military capability was actually growing faster or slower than military expenditure.

Table 3

ANNUAL GROWTH RATE OF SOVIET ME AND MF

	1967-1972	1972-1977	1967-1977
Military expenditure	4.3	3.7	4.0
Military force potential	4.6	4.0	4.3

¹⁸Replacement investment would be growing at an annual rate of 4 percent and would not be a constant proportion of the capital stock. If the underlying depreciation rates for the asset types are not constant, one of the assumptions of the analysis is violated. However, the aggregate depreciation rate will not be constant, even when the individual rates are constant, unless the different capital types are growing at the same rate. For purposes of illustrating the computation of force potential, it seems appropriate to treat replacement investment as if it equals depreciation. On p. 31, there is an additional discussion of this issue.

There are many ways in which sensitivity analysis can be accomplished to obtain some feeling about how changes in the values of the variables affect the numerical results. One calculation is the determination of the size of military capital stock needed in 1967, other things equal, to reduce the annual growth rate of military force potential during the ten-year period to 4 percent—the growth rate of military expenditure during the period. This calculation yields a 1967 military capital stock equal to 299.9 billion rubles, which is higher than the high estimate of 241.7 billion rubles indicated above.

Also, the application of U.S. service lives to the military equipment and structures in the Soviet Union merits additional analysis. This application results in average service lives for Soviet military equipment and structures of 18.6 years and 50 years respectively. It is interesting to compute the levels of Soviet military force potential for alternative service lives, when the other assumptions used to compute net investment are retained. For example, gross investment is still assumed to be growing at an annual rate of 4 percent.

If the Soviet service lives equal 70 percent of the U.S. values, net investment would equal about 43.5 percent of Soviet gross investment by Eq. (3.13). However, if the actual service lives are 30 percent greater than in the United States, net investment would be 64.3 percent of gross investment. These proportions can be used to compute alternative military capital stocks for 1967 using the averaging procedure described above. Under the "short-service life" assumption, the computed military capital stock for 1967 equals 172.8 billion rubles; it is 198.0 billion rubles under a "long-service life" assumption.

Starting with these alternative military capital stock estimates for 1967, short and long-life military capital stock estimates are computed for each year through 1977 by augmenting the estimates with their levels of net investment.

To compute military force potential, the values of military expenditure and RDT&E indicated in Table 2 are retained. The values of net investment and the interest charge on military capital are replaced with their short and long-life alternative. Table 4 summarizes the values of military force potential computed using the alternative service life assumptions. The alternative service life assumptions do not lead to significant changes in the levels of military force potential. One can understand why this is the case by examining Eq. (3.10), and considering a reduction in net investment. If net investment is lower than some base level, say because the service life is shorter, then a smaller amount is subtracted from military expenditure when force potential is computed. However, a lower net investment level implies that the interest charge on military capital is also lower, so a smaller amount would be added to military expenditure. Therefore, the two changes tend to offset each other somewhat.

There is a slight change in the growth rates of military force potential, from those indicated in Table 3. The alternative growth rates are summarized in Table 5.

Table 4

ALTERNATIVE MILITARY FORCE
POTENTIAL COMPUTATIONS
(Billions of 1970 rubles)

Year	Short-Service Life	Long-Service Life
1967	42.6	41.7
1972	52.1	52.9
1977	62.2	65.1

Table 5

ALTERNATIVE GROWTH RATES FOR MILITARY FORCE POTENTIAL

	1967-1972	1972-1977	1967-1977
Short-service life	4.1	3.6	3.9
Long-service life	4.9	4.2	4.5

Under the short-service life assumption, the growth rates of military force potential decline somewhat from the base levels and are slightly lower than the growth rates for military expenditure. The reason for the decline is that the military capital stock is growing more slowly under the short service life assumption. Under the long service life assumption, military force potential is growing slightly faster than the base levels because the military capital stock is growing more quickly.

The three alternative military force potential computations lead to estimated growth rates that are roughly equal to the growth rate of military expenditure. The short service life growth rate of military force potential is slightly lower than the military expenditure growth rates of Table 3, while the "base-case" and long service life growth rate of military force potential are slightly higher than military expenditure growth. But as I have indicated, the calculated values of military force potential should be viewed only as hypothetical. Before any firm conclusion can be made concerning the relationship between military expenditure and military force potential, an accurate military capital stock series is needed.

MILITARY FORCE POTENTIAL ASSUMPTIONS

A number of assumptions have been used to derive the military force potential index. First, there is an absolute measure of aggregate military output called military force potential and it depends *systematically* on the levels of manpower, capital, and material inputs in the military establishment; further, this well defined "production relationship" is characterized by *constant returns to scale*; and finally, the military inputs are, in some sense, used *efficiently* in producing military output. Particular attention is paid to the validity of these assumptions in the context of Soviet decisionmaking.

The proposed output measure is intended to be somewhat akin to such measures of effectiveness as the firepower indexes proposed for evaluating military forces.¹⁹ A firepower measure such as the rounds per weapon per hour for an 8-inch howitzer represents a capability of the howitzer that does not depend on its relative combat effectiveness. It is an "absolute" index. Similarly, military force potential attempts to identify something like firepower at the aggregate level that does not depend on the adversary's capabilities. Of course, an aggregate measure of "firepower" must somehow combine the outputs achieved by the diverse military assets that perform so many roles.

¹⁹For a discussion of their use, see J. A. Stockfish, *Models, Data, and War: A Critique of the Study of Conventional Forces*, The Rand Corporation, R-1526-PR, March 1975.

Before I show why military force potential succeeds in doing just that, it is appropriate first to consider whether there is likely to be a systematic relationship between military output and the assets belonging to the defense establishment of a society like the Soviet Union. Is there a consistently defined relation between inputs and military output—a production function?

One characteristic of a command economy is that policy tends to be articulated with a single voice—the party line—and great care is taken to insure that there are no inconsistencies in its presentation.²⁰ This suggests that there should be a well behaved although implicitly defined relationship between the inputs (whose allocation is determined by the decisionmakers) and military output; there is a consistently defined military doctrine. It is also true that decentralized implementation of a centralized plan can impair the prescribed relation between the inputs and military output. During plan implementation, constraints do change, and the values of individual decisionmakers may succeed in nullifying somewhat the social values embodied in the formulated plan. However, if the plan is sufficiently well defined, so as to give the individual decisionmakers some sense of the approved tradeoffs, there may still be some measure of consistency in the allocative decisionmaking. This suggests that divergencies between the formulated and the implemented tradeoffs may cancel in some aggregate sense and that the average relationship between the inputs and military output would be a consistently defined relationship. In fact, one observer has commented, "Soviet military doctrine . . . has remained more or less internally consistent and conceptually stable since around 1960."²¹

Given the existence of a well defined relationship between the inputs and military output, the assumption of cost minimization enables a U.S. policymaker to identify relative values of different weapons in the Soviet Union's own terms: The subjective rate of substitution of the services of, say, an SS-19 for a MiG-25 in military consumption is equal to the objectively defined rate of productive transformation of one asset's services for those of the other. Under cost minimizing behavior, the last ruble spent on an SS-19 yields the same subjectively defined additional military output as the last ruble spent on a MiG-25. Price is proportional to military productivity, and the inputs properly weighted by their prices are a valid measure of military output.

Is there any evidence that the Soviets are minimizing costs? They may at least be responding to changes in input prices, which is consistent with this behavior pattern. Between 1967 and 1977, military investment expenditures in the Soviet Union grew at about 4 percent a year while personnel spending grew at a rate of 2 to 3 percent a year. Both expenditure categories are measured in 1970 rubles.²²

It is reasonable to believe that the faster growth rate for investment was in response to relative price changes. If the U.S. prices are like late-period Soviet prices, then the Soviet relative prices may be converging toward those in the United States. That is, the actual Soviet prices during the 1970s might have moved toward the U.S. relative prices of 1979, which are used to compute military expenditure in dollar terms.

²⁰The analogy in the United States is the annual military posture statement, which helps define the military values of the United States. For example, see *Department of Defense Annual Report, Fiscal Year 1980*, a report of Secretary of Defense Harold Brown, submitted to the Congress on the FY1980 Budget FY1981 Authorization Request and FY1980-1984 Defense Programs, Washington, D.C., January 25, 1979. Also, for a discussion of the increased use of PPBS techniques in the Soviet Union, see P. Cocks, "The Policy Process and Bureaucratic Politics," in *The Dynamics of Soviet Politics*, P. Cocks, R. Daniels, and N. Heer (eds.), Harvard University Press, Cambridge, Massachusetts, 1976.

²¹B. S. Lambeth, *How To Think About Soviet Military Doctrine*, The Rand Corporation, P-5939, February 1978, p. 17. An exception mentioned by Lambeth is "on the question of whether a conventional war in Europe will 'eventually' escalate to the nuclear level" (p. 17).

²²CIA, *Estimated Soviet Defense Spending*, pp. 2-3.

Is there any direct evidence of relative price changes? The Soviet economy has been experiencing a faster growth of its capital stock than of its labor force, and the marginal product of capital has been diminishing while output per man has been continuing to rise.²³ Investment goods have been becoming *relatively* cheaper while labor is becoming more expensive. The Soviet military's increased orientation toward investment goods is consistent with a purposive reaction to the change in relative prices. This is precisely the type of reaction that would occur under the cost-minimization hypothesis.

An additional assumption that needs to be addressed is that the production function is characterized by constant returns to scale. This means that a proportionate change in all resource inputs leads to a like change in military output. The assumption of constant returns to scale permits differences in military output to be compared. One year's change in military force potential can be compared with a change in military expenditure or with another year's change in military force potential.

If a policymaker is only interested in knowing whether military output has risen, the imputed expenditure level provides a perfectly valid measure of the direction of output change, even if constant returns to scale are not assumed. As imputed expenditure increases, so also does military output. However, a policymaker may be interested in knowing how much of a change has occurred and may want to compare these changes over time. To aid in this "sizing of a change," constant returns to scale may be the most reasonable assumption to make. Although one may not agree with this assumption, it is at least possible to understand precisely what is being assumed so that subjective judgment can be intelligently applied to the computed changes. All of this suggests that a policymaker be very careful when interpreting a percentage change in military force potential as a measure of the size of an output change.

As indicated above, a perfectly legitimate interpretation of the size of a change in military force potential does not depend on the constant returns to scale assumption. The index can be used to compare changes in the value of the resources used to produce military output with changes in military expenditure. In other words, the index can be used to make judgments about the size of the inputs used to produce military output. If military force potential is growing faster than military expenditure, the value of the resources devoted to producing military output is growing faster than the total resources being used by the defense establishment.

Whether the percentage changes in computed military force potential correspond to like changes in actual military output is a question that requires experienced military and political judgment to answer. At the very least, the assumption of constant returns to scale provides a reference path from which experienced judgment can move.

The index of Soviet military force potential is an absolute rather than a relative measure of military output. A relative measure would compare the Soviet's output relative to the index of military force potential for the United States. Such a comparison leads to a measure of relative military power, which is developed in the next section. This measure is used to calculate changes in the relative levels of military force potential that occurred between the United States and the Soviet Union.

²³See M. L. Weitzman, "Soviet Postwar Economic Growth & Capital Labor Substitution," *American Economic Review*, September 1970, pp. 676-92.

IV. RELATIVE MILITARY POWER WITHIN THE LONG-TERM COMPETITION

National security is inherently a relative process. It depends (among other things) on the capabilities of both U.S. and Soviet forces. Although such issues as the role played by the Peoples Republic of China affect the U.S.-Soviet relationship, there is a long-term competition between the United States and the Soviet Union. By summarizing various aspects of the military balance in a single indicator, one can better understand the degree to which U.S. military assets as challenged by those of the Soviets are capable of supporting the U.S. position as a military power.

In this section, an aggregate measure of U.S. relative military power (MP_A) is proposed that is equal to the ratio of the level of U.S. military force potential (MF_A) to that of the Soviet Union (MF_R). As discussed in Sec. III, military force potential is an absolute measure of the level of military output achieved by a defense establishment. The ratio of the two nations' military output levels measures the "degree" or relative level of national security achieved during some period. As is the case with the military force potential index, the most interesting use of the relative power index is in the representation of changes that have taken place over time. It is shown below that there was a decline in calculated U.S. military force potential between 1972 and 1977. As the computations of Sec. III measure a rise in Soviet force potential during the same period, a decline in U.S. competitive position is calculated with the relative military power index. However, the uncertainties associated with the military capital stock and net investment estimates for the Soviet Union make any conclusions extremely tentative.

Before this calculated result is presented, it is appropriate to discuss various obstacles associated with identifying a single index of relative military power. These include the issues of aggregation, interaction, and the relative valuation of the forces in both nation's military arsenals.

AGGREGATION, INTERACTION, AND VALUATION

An aggregate measure of relative military power is a summary measure of the *relative* capabilities of the military assets in the United States and the Soviet Union. Of course, any aggregate indicator of military power is not the only measure used or useful. The entire microspecification of the U.S. and Soviet order of battle and the analysis of the various balances are important: How many and what kinds of tanks have the United States and the Soviet Union deployed in Europe? What principles of military doctrine govern their use? There has been extensive analytical response to these types of questions, but there is also a demand for a single indicator that aggregates all the manpower, military capital, and material in *both* nations' arsenals. This indicator would complement the various micro-indicators and be an aid in understanding the status of the competition by monitoring the overall balance. Specifically, one advantage that an overall indicator would have is that it would encompass some of the valuation interdependencies among the various types of military equipment. For example, the value of additional tanks on one side depends on the capabilities of that side's tactical aircraft. When aggregating military assets, the military force potential index does properly account for the valuation interdependencies among one side's assets when the capability level of the

adversary is held constant. However, a relative power index attempts to measure the implication of changes in the adversary's capabilities. If military interactions occur exclusively at a micro level, then it would not be legitimate to compare one side's aggregate capability level directly with the other's.

Many of the important interactions seem to occur at the micro level. The net effectiveness of a tank brigade depends on its own capabilities as well as the capabilities of the opponent's tanks and antitank weapons. This net effectiveness probably does not depend *substantially* on the ICBMs in the opponent's inventory. But there is still an important sense in which the *net* effectiveness of *all* conventional forces on one side depends on the capabilities of strategic forces on both sides; there are important macro interactions. Perhaps even more important, one side's perception of overall military power depends on the values of various aggregate indicators. Aggregate measures are necessary to comprehend a complicated situation. It may be meaningful to relate an aggregate measure of one side's military output to the aggregate measure on the other side. But how should the other side's assets be aggregated?

Although military force potential is an aggregate measure of military output, the cost-minimization assumption implies that this output measure is based on a military establishment's own evaluation of the relative productivity of its different military assets. A nation's view of its relative position in a long-term competition is a subjective judgment that would be based on its valuation of all the military assets on both sides. Two adversaries probably value the total assets differently. There are differences in military doctrine.

To reduce the problem of differing military asset valuation to manageable proportions, it is helpful to view U.S. military forces as contributing to two basic goals in the military competition: (1) reduce the probability that the Soviets will do "X" (e.g., initiate a conventional war in Western Europe), and (2) increase the probability that the United States can successfully counter "X" given that deterrence has failed (e.g., "win" the conventional war in Europe). The former might be called the deterrence goal, and the latter might simply be called the war-fighting goal.

U.S. analysts and policymakers have argued that deterrence may be achieved either by threat of punishment or by denial of some objective. For example, Secretary of Defense Harold Brown has stated:¹

Deterrence is usually seen as the product of several conditions. We must obviously be able to communicate a message to the other side about the price it will have to pay for attempting to achieve an objective unacceptable to us. We must have the military capabilities necessary to exact the payment (at a cost acceptable to ourselves), whether by denying the opponent his objectives, by charging him an excessive price for achieving them, or by some combination of the two.

The view that there are two types of deterrence suggests that there may be a tradeoff faced when one is attempting to achieve the proper mixture of forces; e.g., an inaccurate ICBM may yield a substantial amount of military value even if it does not strengthen war-fighting capabilities.²

In contrast to the United States, the Soviet Union tends to discount the view that deterrence can be achieved by threat of punishment. They feel that the deterrence and war-fighting objectives are mutually supportive: "Soviet strategic pronouncements typically maintain that

¹Department of Defense Annual Report, Fiscal Year 1980, 25 January 1979, p. 61.

²Inaccurate Soviet ICBMs can probably be traced to supply side technological constraints. The improvements in missile accuracy are evidence that they are demanding the type of capability commensurate with successful war fighting.

the only acceptable deterrence is one that rests on the intrinsic capabilities of Soviet forces rather than the rationality and good will of the enemy."³ Such a doctrinal view implies an unwillingness to devote resources to any military equipment that does not directly contribute to war fighting.

Military doctrine is very much to the point when one is developing a measure of potential military power. Doctrine is an expression of the way assets are valued; it helps define the preference indicator describing the achievement of national security. The United States would have its strategic values embodied in its indicator, and the Soviet Union would correspondingly have Soviet values embodied in its indicator. If there are fundamental doctrinal disagreements, say on the matter of the relationship between deterrence and war fighting, then in principle, each side in the competition should weight both its own and its adversary's assets in its own terms.

Although this argument is valid, it leads to an empirical impasse. There are no readily available data indicating how we value the Soviet's military assets. However, we can observe how they value their own assets; the military force potential index for the Soviet Union summarizes its valuation information.

Because the revealed preferences of the Soviets provide us with clues about how they might conduct the long-term competition, such information could well influence our military doctrine; the opposite might be true for the Soviet Union. Within the context of a long-term competition, military doctrine might very well converge. To the extent that there is a convergence in military doctrine—a movement toward a symmetry of strategic values—then it becomes all the more legitimate to directly compare the measured military force potential of the U.S. and Soviet defense establishments.

Although such a convergence may occur in the long run, there is a demand for an aggregate indicator of relative military power. We need to evaluate current trends. Subject to all of the qualifications associated with the aggregation, interaction, and valuation issues, it is judged that meaningful information about the relative military power of the United States can be obtained by comparing the U.S. indicator of military force potential with that of the Soviets. The comparison is best made with the aid of an aggregate preference indicator.

U.S. AGGREGATE PREFERENCE INDICATOR

Other things equal, the U.S. preference indicator describing its level of relative military power is assumed to depend on the level of force potential in the United States and the Soviet Union:

$$MP_A = f(MF_A, MF_R). \quad (4.1)$$

There are many tradeoff possibilities permitted by a general preference indicator such as Eq. (4.1). For example, the general function admits the possibility that U.S. forces are too large relative to the Soviets. This outcome might be the case in an actual competitive situation. As Secretary of Defense Harold Brown has stated:⁴

It is all well and good to say that we want both deterrence and stability. But how do we know that we are strong enough to deter, but not so strong as to drive the other side to actions detrimental to both.

³Lambeth, *How To Think About Soviet Military Doctrine*, pp. 6-7.

⁴Department of Defense Annual Report, Fiscal Year 1980, 25 January 1979, p. 61.

If the U.S. force level is too large relative to that of the Soviets, then an increase in Soviet military force potential could improve well-being in the United States. Although such a possibility needs to be considered, it is assumed that the current competitive environment is best characterized by a positive tradeoff between U.S. and Soviet military force potential: For the U.S. level of national security to remain constant following a rise in Soviet capability, it is necessary that U.S. capability increase.

The identification of the tradeoff curves of Eq. (4.1) describing how large an increase in U.S. capability is required to offset a Soviet increase in military output is very interesting from a policy standpoint. It tells the decisionmaker how much additional U.S. resources must be devoted to military output, following an adversary's buildup, to return the level of national security to the original level (the *status quo ante*). However, even though knowledge of the indifference curves generated by Eq. (4.1) is interesting and important information, it fails to indicate anything about the size of a decline in security contrived by an adversary. Indifference curves indicate only what must be done to negate the effect of a buildup. When deciding whether an opponent's buildup should be fully offset or not, one should also have some sense of the size of the reduction in national security.

To compute an indicator that reflects the size of a change in national security, the following assumption is made: Increases in U.S. military force potential and decreases in Soviet military force are symmetrical, and both lead to proportionate increases in U.S. relative military power. For example, a 1 percent increase in U.S. military force potential results in a 1 percent increase in U.S. relative military power; so does a 1 percent decrease in Soviet military force potential. This assumption is made because its implications are easily understandable and also because it leads to a particularly sharp characterization of U.S. relative military power. Under this assumption, the U.S. relative military power indicator equals the ratio of U.S. military force potential to that of the Soviet Union.

$$MP_A = MF_A/MF_R. \quad (4.2)$$

Equiproportional changes in each side's military force potential leave relative military power unchanged. This may be an attractive property for an index of relative military power to have.

The *level* of relative military power computed used with this ratio actually has limited value; there is no reference point indicating what value of the ratio represents parity.⁵ However, the *percentage change* in the relative military power indicator is a figure of interest.

RELATIVE MILITARY FORCE POTENTIAL

To illustrate the computation of the relative military power indicator, an estimate is made of U.S. military force potential for 1972 and 1977.⁶ These force potential levels are divided by the corresponding levels of Soviet military force potential, which were computed in Sec. III, and the percentage change in the relative military power indicator is calculated. In view of the

⁵Some appreciation for the "size" of Soviet military force potential could be obtained by estimating this output indicator in dollar terms. To obtain a dollar estimate of Soviet military capital, dollar-ruble ratios would need to be applied to its components.

⁶This is the second half of the period for which the CIA has estimated spending in ruble terms as reported in *Estimated Soviet Defense Spending*. Although U.S. data are available for 1967-1971, the expenditures associated with the Vietnam war would make it difficult to compare U.S. and Soviet military output.

importance of military force potential in the computation of relative military power, it is appropriate to restate here the relationship between military force potential and military expenditure. As indicated by Eq. (3.10), military force potential equals military expenditure less RDT&E and net investment plus the interest charge on military capital and the capital losses. Net investment, it might be recalled, equals the addition to the capital stock during some time period.

To calculate a military force potential index for the United States, U.S. military expenditure information is used in conjunction with capital stock and depreciation estimates. As indicated in Sec. II, the U.S. Office of Management and Budget has specified that an interest rate of 10 percent should be used to evaluate public sector investments. This interest rate must be applied to the capital stock estimate to obtain the interest charge in military capital. As is the case for the Soviet Union we ignore capital losses in the calculations.

The CIA has reported that U.S. military expenditure, gross military investment, and RDT&E for 1972 and 1977 were as indicated in Table 6. Between 1972 and 1979, U.S. military expenditure declined approximately a 7.5 percent. The declines in gross investment and RDT&E were about 15 percent and 7.5 percent respectively.

Table 6

U.S. MILITARY OUTLAYS^a
(Billions of 1979 dollars)

	1972	1977
Military expenditure	118.9	111.0
Gross investment	29.5	25.0
RDT&E	14.8	13.7

^a*Soviet and U.S. Defense Activities, 1970-79.*

Estimates are also needed of the U.S. military capital stock and net investment for the two periods. The U.S. Department of Commerce has recently developed a U.S. military capital stock series for 1925-1979. Table 7 summarizes the capital stocks values for 1972 and 1977. Also indicated are depreciation estimates obtained by subtracting the values of a one-year change in military during 1972 and 1977 from the gross investment levels indicated in Table 6.

Table 7 indicates that there was little change in the U.S. military capital stock between 1972 and 1977; a modest rise in the value of military equipment was more than offset by the reduction in the value of supply system inventories. Several aspects of these capital stock and depreciation estimates need to be considered. First of all, these capital stock values are estimates of what is called the *gross*-capital stock, which measures the aggregate replacement cost (at constant prices) of all property in the defense establishment. It is the valid measure of the military capital stock if one assumes that the assets are maintained at their original capability level until withdrawn from the inventory. As the levels of Soviet military capital calculated in Sec. III are gross capital stock measures, both nations' military capital stock estimates are based on the same underlying assumption.

An alternative military capital stock estimate has also been provided by the Department of Commerce. This alternative is called the *net*-capital stock and assumes straight-line depreciation of the capital asset throughout its service life: its value declines by a constant

Table 7

U.S. MILITARY CAPITAL AND DEPRECIATION
(Billions of 1979 dollars)

	1972	1977
Total military capital	509.4	508.6
Equipment ^a	289.8	296.6
Structures ^a	146.5	147.7
Inventories ^b	73.1	64.3
Total depreciation ^c	36.7	24.1

^aJ. C. Musgrave, "Government-Owned Fixed Capital in the United States, 1925-1979," *Survey of Current Business*, March 1980. The equipment and structure values in 1972 dollars are summarized on p. 35. Conversion to 1979 dollars is made using price indexes obtained by dividing the current values of equipment and structures in 1979 by their values in 1972 dollars.

^bIn Sec. III, I had included supply inventories in the equipment category. The Department of Commerce distinguishes between equipment and inventories. These preliminary estimates of supply system inventories have been provided by John Musgrave of the Department of Commerce. The estimates include POL, but this constitutes only a small portion of the total. For example, *Real and Personal Property of the Department of Defense as of 30 June 1974*, OASD (Comptroller), Directorate for Information Operations and Control, p. 59, indicates that POL constitutes about 2.8 percent of the supply system inventories.

^cIn 1973 and 1978, the total value of military capital in 1979 prices was about 502.2 and 509.5 billion dollars respectively. Therefore, net investment in these years was \$-7.2 and \$.9 billion. Calculated depreciation equals gross investment from Table 6 minus net investment.

amount each year until the end of its service life.⁷ If there is a decline in the military output produced by an asset as it ages, it is appropriate to take account of this decay when determining military capital. However, at the present time, little is known about the character of military output depreciation either for the United States or for the Soviet Union. Also, there are

⁷See Musgrave, "Government-Owned Fixed Capital in the United States," p. 37. There is a substantial difference between the gross and net capital stock as indicated by the following table, which summarizes values of military equipment and structures for 1972 and 1977.

NET (EQUIPMENT AND STRUCTURES)
CAPITAL STOCK
(Billions of 1979 dollars)

	1972	1979
Total equipment and structures	223.4	225.0
Equipment	145.1	151.2
Structures	78.4	73.8

The values for equipment and structures indicated in Table 7 are about twice these levels; the average age of equipment and structures must be about half its average service life. Estimates of the "net" value of the military supply inventories have not yet been developed.

important examples of systems that remain operational well beyond their official service lives—the B-52 is an important case in point. Therefore, in these computations, the gross capital stock measure seems to be more appropriate.

It can also be noted from Table 7 that the value of depreciation in 1972 is higher than in 1977, while the total value of the capital stock is at about the same level; the calculated depreciation rate is lower in the second year. In deriving Eq. (3.10), I assume the depreciation rate to be constant for each type of military capital; however, the aggregate depreciation rate may still vary over time. This constant rate assumption insures that actual depreciation equals the value of the capital withdrawn from the stock and greatly simplifies the calculation of the cost of the capital services provided during some given period. In the calculations, it is probably best to use the analytical results of the constant depreciation rate model. More detailed analysis is required to determine if an underlying assumption is violated.⁸

After applying the 10 percent interest rate to the total military capital stock estimates of Table 7 for 1972 and 1977, and deducting total depreciation from the level of gross investment for those years, one obtains the remaining information needed to utilize Eq. (3.10). Table 8 summarizes the information needed to calculate U.S. military force potential for the two years and the resulting values of this output indicator. The reduction in military force potential from 162.2 to 146.3 billion dollars implies that there was almost a 10 percent reduction in U.S. military capability during this time period.

Table 8

U.S. MILITARY FORCE POTENTIAL ELEMENTS
(Billions of 1979 dollars)

	1972	1977
Military expenditure	118.9	110.0
RDT&E	14.8	13.7
Net investment	-7.2	.9
Interest charge on military capital	50.9	50.9
Military force potential	162.2	146.3

Table 2 indicated that Soviet military force potential equaled 52.5 billion rubles in 1972 and 63.8 billion in 1977. These are the values obtained when U.S. military service lives are used to estimate the average lives of Soviet military equipment and structures. The increase in military force potential indicates that there was a 21.5 percent increase in Soviet military capability during the period. Using Eq. (4.2), one can compute the calculated values of the relative military power index for 1972 and 1977. However, as I have indicated, these levels are not amenable to ready interpretation; it is the percentage change in relative military power that is of interest. This percentage change for the five-year period equals -25.9 percent. Table 9 summarizes the calculated percentage changes in military output and relative military power that occurred between 1972 and 1977. Of course, all of the assumptions of this analysis must be kept in mind when one interprets these index numbers.

⁸As discussed in Feldstein and Rothschild, "Towards an Economic Theory of Replacment Investment," a constant depreciation rate will eventually be achieved if all components of gross investment are growing at the same constant rate. There is an additional discussion of the constant (or exponential) depreciation rate assumption in *The Economics of Military Capital*.

Table 9

CHANGE IN OUTPUT AND RELATIVE MILITARY POWER
1972-1977

	Percentage Change
U. S. Military Force Potential (MFA)	- 9.8
Soviet Military Force Potential (MFR)	+21.5
U. S. Relative Military Power (MPA)	- 25.9

Improvement in the accuracy of the proposed indexes would be best achieved by monitoring the size of both the U.S. and Soviet military capital stock; information on net investment would be simultaneously generated. In a calculation of military capital stock size, the question of depreciation merits careful consideration. Does the capability of military assets decline over time, and how? The paucity of data for the Soviet Union has required us to assume that assets are maintained at their original capability level until they are withdrawn from the capital stock. It would be appropriate to determine whether some other pattern of depreciation applies to the Soviet Union as well as to the United States.

Although the estimated levels of military force potential for the United States and the Soviet Union as well as the measure of relative military power are by no means the whole story of the military relationship between the two countries, they do complement the extensive micro analyses that are already being done.

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